March 25, 2003

Ms. Jennifer Hutchison
Indiana Department of Environmental Management
Office of Water Quality
2525 North Shadeland Avenue
Indianapolis, IN 46219

Dear Ms. Hutchison:

RE: *E. coli* TMDL for the Trail Creek Watershed
Watershed and Water Quality Modeling/Analytical Framework Report
Triad Engineering Incorporated Project No. I023557

INTRODUCTION

The Indiana Department of Environmental Management (IDEM) has contracted with Triad Engineering Incorporated (Triad) to develop an *E. coli* Total Maximum Daily Load (TMDL) for the Trail Creek Watershed located in LaPorte County IN. As part of the effort, a *Watershed and Water Quality Modeling/Analytical Framework Report (Modeling Framework Report)* is required per Task 10 of the Supplement to Master Agreement for Technical Services. This report will address the following major issues:

- Description of modeling objectives;
- Description of the proposed modeling framework;
- Description of alternative watershed modeling frameworks;
- How the model will satisfy the modeling objectives; and
- Consideration of stakeholder input.

MODELING OBJECTIVES

The Trail Creek Watershed model will need to be capable of analyzing watershed runoff, associated *E. coli* loadings and the ultimate fate and transport of E. coli in the receiving waters of the watershed. This capability is required to provide IDEM with a technically defensible watershed model for:

- Identifying the loading capacity of Trail Creek for *E. coli* bacteria at critical environmental conditions;

- Identifying cause and effect relationships between sources and Trail Creek *E. coli* levels for determining attainment with State Water Quality Standards (SWQS);

- Developing, testing and evaluating potential *E. coli* allocations, which will include wasteload allocations for point sources (WLA), load allocations for nonpoint sources (LA) that include an appropriate margin of safety (MOS);

- Testing and evaluating implementation alternative compatible with the State's NPDES Permitting and Compliance Programs.

The watershed model will need to be time-variable (i.e., model calculations completed during a time period such as wet, dry or average rainfall/runoff year) or at least be able to address *E. coli* levels in the watershed on a seasonal basis. This is required to address seasonal variations when determining allocations in the watershed.

DESCRIPTION OF THE SELECTED MODELING FRAMEWORK

The proposed Trail Creek Watershed modeling framework is comprised of two components:

- A watershed model (GWLF) to calculate runoff quantity and quality due to factors such as rainfall, land use/cover and soil type; and

- A receiving water quality model (WASP) to calculate water quality in major streams in the watershed due to the watershed loadings, dilution and chemical/physical/biological reactions.

Both of these models can be applied in a time-variable mode (e.g., daily inputs such as rainfall or loads, and outputs of *E. coli* concentration) and provide suitable modeling frameworks for analyzing water quality and for developing TMDLs in the watershed. A brief description of each model is presented below as adapted from the associated User's Manuals with more detail located at the listed websites.

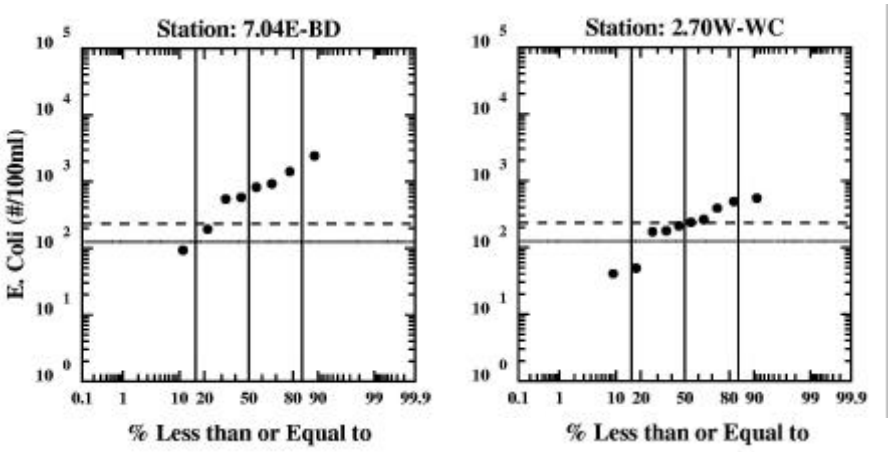
Generalized Watershed Loading Functions (GWLF)

The GWLF model is a mid-range watershed model that is more detailed than empirical export coefficient approaches (e.g., unit area loadings) but less complex than mechanistic (mass balance) simulation models. GWLF allows daily input of rainfall and temperature with the assignment of associated watershed characteristics such as land use and soil type. Surface runoff and groundwater sources are included as well as loads from point sources and septic systems. The Soil Conservation Service Curve Number Equation is used to calculate watershed runoff quantity and groundwater discharge is determined from a watershed water balance. This water balance includes infiltration to the unsaturated and shallow saturated zones in excess of rainfall and snowmelt minus runoff and evapotranspiration.

The GWLF model was originally designed for calculating nutrient and solids loads from watershed runoff but will be used to generate bacteria loads based on the computed runoff quantity and an assigned concentration (as currently completed for nutrients). Either constant *E. coli* runoff concentrations or variable concentrations based on assigned means and variations will be used. The latter method of assigning runoff concentrations is aimed

at reproducing the observed variation in measured *E. coli* concentrations in the watershed. For instance, monitoring data at upstream locations in the watershed that receive little dilution flow and are not impacted by bacteria sources may be used to determine runoff/groundwater bacteria concentrations. Two upstream stations in the Trail Creek watershed are presented below as probability distributions: station 7.04E-BD is located in an agricultural area and station 2.70W-WC is located in a forested area. The median and variation of these datasets could be used to establish runoff concentrations for agricultural and forested areas with the variability assumed to reflect non-flow related variations. Selection of the concentration assignment method will be determined during the calibration effort.

Calibration of the GWLF model will be primarily to stream flow with calibration of *E. coli* levels primarily completed with the WASP model, although there will be overlapping calibration efforts. Since calibration to daily stream flow can be difficult due to a number of complicating factors such as small-scale land use, soil type and surface/groundwater interactions, GWLF runoff will be calibrated to monthly flow totals. In addition, site-specific rainfall will not be



available for calibration and one rainfall record may only be available for the entire watershed. This is another complicating factor in calibrating watershed models to daily stream flow. There is only one active USGS flow gage in the watershed (Michigan City Harbor #04095380), which is located near the mouth of Trail Creek with Lake Michigan and is occasionally influenced by lake water levels. One retired USGS flow gage is located in the watershed (Michigan City #04095300) approximately 4 miles upstream from the mouth, which was discontinued in 1994. In order to calibrate stream flow in the east and west branches of Trail Creek, stream flows will be estimated from the USGS gages based on a drainage area ratio approach.

Additional technical details of the GWLF model can be obtained at: www.vims.edu/bio/models/bsabout.html.

Water Quality Analysis Simulation Program (WASP)

The WASP model is a multi-purpose model that can be applied in 1-, 2- and 3-dimensions for a variety of water quality processes (e.g., eutrophication, BOD-DO, bacteria, toxics) in rivers, lakes, reservoirs, estuaries and coastal water bodies. In addition, the structure of the WASP model allows user specific models to be developed and applied to meet specific project needs. The WASP model can be applied in a time-variable mode, which is a great advantage over other stream models that are steady state such as QUAL2E. WASP is a dynamic compartment model that is based on the key principle of the conservation of mass. Water transport can be determined by the included hydrodynamic model (DYNHYD), other external hydrodynamic models, or defined based on the assignment of river flow and stream channel geometry. For the Trail Creek application, stream flow will be assigned based on the computed runoff and groundwater sources. Stream geometry will be determined from the best available data or previous modeling studies and allowed to vary as a function of stream flow based on typical flow power functions (e.g., $Depth = a \times Flow^{b}$).

The mainstream reaches in the Trail Creek Watershed will be segmented for application of the WASP model with length, width and depth assigned for each model segment. Segment length will be assigned to maintain model stability and minimize numerical dispersion. The water quality component of the WASP model will include bacteria die-off as the main loss rate with sources from runoff and groundwater loadings, point sources, combined sewer overflows, and direct/indirect discharge from dairy/steer farms. The model will be run in a time-variable mode and, therefore, all inputs will also be assigned as a function of time (e.g., daily). Time-variable output from the WASP model will be compared to the observed watershed data for calibration to stream *E. coli* concentrations.

Additional technical details of the WASP model can be obtained at:
www.epa.gov/region4/water/tmdl/tools/wasp.htm.

DESCRIPTION OF ALTERNATIVE WATERSHED MODELING FRAMEWORKS

The purpose of model selection is to provide a complete and concise modeling framework that will solve the environmental problem under consideration for the selected watershed. Presented below are alternative public domain watershed modeling tools, associated capabilities, and reasons why they were found unsuitable for the Trail Creek watershed. Modeling frameworks A through C are alternatives to the recommended GWLF model.

A. Hydrologic Simulation Program Fortran (HSPF) – The HSPF model is a continuous simulation model designed to analyze dynamic events or steady-state processes for many water quantity and quality processes that occur in a watershed. It is a lumped parameter model (i.e., each watershed or sub-watershed uses the same input parameters to describe associated processes), which is relatively complicated and requires extensive input parameters.

B. Storm water Management Model (SWMM) – The SWMM model is a comprehensive model that can predict flows, stages and pollutant concentrations

for continuous and steady state events in urban catchments with storm sewers or combined sewers and in natural drainage areas. It has been primarily used for sewer system modeling but it has also been utilized for analyzing watershed runoff and pollutant loadings.

C. Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) – The HEC-HMS model is a comprehensive model for analyzing detailed watershed processes in dendritic watershed systems. This model was developed by the United States Army Corps of Engineers (USACE) and includes processes associated with detailed channel hydraulics and watershed runoff.

The reasons for not selecting the HSPF, SWMM, or HEC-HMS models are due to their complexity. These models are generally defined as deterministic or mechanistic and typically require a large amount of site-specific physical data to describe the watershed. The imbalance between the required model information (input and calibration data) and the available data is the primary reason for not selecting these models. In addition, Trail Creek TMDL needs and schedules also factor into the selection process. The detailed models require more time and expense to develop a technically reliable watershed model that can be used for completing TMDL related efforts. Therefore, a watershed model with data requirements more similar to the available data but still capable of reliably representing the processes in the watershed is more suitable for application (i.e., the GWLF model). The GWLF model is a lumped parameter model that calculates runoff based on rainfall and watershed parameters and uses statistical relationships for runoff quality represent the watershed loads that are delivered to Trail Creek.

Presented below are alternative public domain stream modeling tools, associated capabilities, and reasons why they were found unsuitable for the Trail Creek watershed. Modeling frameworks D and E are alternatives to the recommended WASP model.

D. QUAL2E – The QUAL2E model is a steady-state stream water quality model capable of analyzing a variety of instream pollutant processes. These processes include reaction pathways associated with biological oxygen demand (BOD) decay, ammonia nitrification, atmospheric oxygen reaeration, sediment oxygen demand, bacteria die-off, and nutrient related algal growth. The QUAL2E model was not selected for the Trail Creek watershed because it is a steady-state model and not capable of representing the time variable concentration of e.coli needed for the TMDL project.

E. CE-QUAL-RIV1 – The CE-QUAL-RIV1 model is capable of analyzing continuous and steady state river hydraulics and water quality. It contains both a hydraulic component to calculated water stage, cross-section and flow and a water quality component that calculates water quality constituents similar to QUAL2E. The CE-QUAL-RIV1 model was not selected for the Trail Creek watershed also because of its complexity and general development for describing detailed channel hydraulics and associated water quality.

Although these models were not immediately selected for the Trail Creek watershed, as more detailed or site-specific environmental questions are posed these models may become applicable.

Model Calibration

Calibration of the GWLF and WASP models will be completed for an annual period. Selection of the period will depend on a number of factors such as: instream data availability, rainfall and stream flow statistics (e.g., average, wet or dry year), and bacteria loads. The instream bacteria data reviewed to date covered the time period from 1998 to 2001 and, therefore, the calibration period will be selected from those time periods. Average annual stream flow at Michigan City Harbor and total rainfall for 1998 was 128 cfs (29"), for 1999 was 127 cfs (25"), for 2000 was 121 cfs (30"), and for 2001 was 112 cfs (34"). Given the similar average annual stream flow for these years, the final selection will most likely be dictated by the best data coverage at the monitored stations throughout the watershed.

The time-step of the models (frequency of model inputs) will be determined based on a review of stream hydrographs to determine the duration of flow events due to rainfall. In addition, the availability of input data (daily vs. hourly) may ultimately determine the time-step used in the models. It is anticipated that a time-step of 1-day will be used, but the stream hydrograph and input data review will determine whether a smaller time-step is required (e.g., 3-hr or 6-hr).

HOW MODEL WILL SATISFY OBJECTIVES

The selected watershed model (GWLF) and receiving water model (WASP) were both selected to provide the necessary components to properly represent *E. coli* loading, fate loading and transport in the Trail Creek Watershed. That is, the models will relate rainfall runoff and groundwater sources (nonpoint sources), point sources and instream fate and transport to *E. coli* levels in the Trail Creek Watershed (cause and effect relationships). After calibration of the models, they will be suitable for determining the loading capacity of Trail Creek for developing load allocations and testing implementation alternatives which will be useful in State permitting and compliance programs. It should be stressed that the level of calibration will be critical in determining the overall success of meeting the modeling objectives. A poorly calibrated model can answer the questions posed but with large uncertainty. The goal of the Trail Creek modeling effort will be to provide the best level of calibration that can be achieved given the available data and understanding of the watershed that minimizes model uncertainty so that informed decisions can be made.

HOW STAKEHOLDER INPUT WILL BE CONSIDERED

After IDEM approval of the *Modeling Framework Report*, a watershed stakeholder meeting will be held to present the selected modeling approach and intended uses of the model. Comments from the stakeholders regarding the *Modeling Framework Report* will be compiled, reviewed and taken into consideration when developing the Trail Creek Watershed

Model.

Following the completion of the modeling and preparation of the Allocation Report, results will be presented to stakeholders in a meeting where the draft TMDL will be introduced. Stakeholder comment will be reviewed and incorporated in the final TMDL Report, if appropriate.

Sincerely,

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